

**CLAIMS**

1. A hub drive system for a vehicle, comprising:
- 5 a) a tubular housing suspended by the vehicle and having an inboard and an outboard end;
- b) a wheel hub rotationally mounted on the outboard end of the housing;
- c) an electric motor disposed in the inboard end
- 10 of housing;
- d) a planetary gearbox, disposed in the outboard end of the housing and driven by the motor through a hollow primary shaft;
- e) an output flange of the gearbox operatively
- 15 connected to the hub,
- f) a casing for the motor;
- g) a stator in the casing;
- h) a hollow rotor rotationally mounted in the casing and operatively connected to the primary shaft of
- 20 the gearbox;
- i) a gallery defined between the housing and casing and into which a lubricant for the gearbox is injectable to cool the motor;
- j) a passage in the casing to deliver lubricant
- 25 from said gallery to said hollow rotor to further cool the motor; and
- k) said rotor being arranged to deliver said oil to the primary shaft to lubricate the gearbox.
- 30 2. A drive system as claimed in claim 1, in which the motor casing has a substantially cylindrical outboard end sealed and centred in the housing by an O-ring.

3. A drive system as claimed in claim 1 or 2, in which the casing is a sliding fit in the housing to permit inboard access to the motor without any need for a wheel removal.

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4. A hub drive system for a vehicle, comprising:

a) a tubular housing suspended by the vehicle and having inboard and outboard open ends;

b) a wheel hub rotationally mounted through hub bearings on the outboard end of the housing;

c) an electric motor disposed in the inboard end of the housing;

d) a planetary gearbox, disposed in the outboard end of the housing within the radial confines of said bearings and driven by the motor through a primary shaft;

e) an output flange of the gearbox detachably connected to the hub and closing the outboard end of the housing; wherein

f) without removing the wheel, the motor is removable inboard of the housing and the gearbox is dismantlable primarily outboard of the housing.

5. A drive system as claimed in claim 4, in which the primary shaft of the gearbox is rotationally supported in the hub.

6. A drive system as claimed in claim 5, in which the other, inboard end of the primary shaft is journalled in the motor.

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7. A drive system as claimed in claim 4, 5 or 6, in which the motor has a casing, a stator fixed in the casing and a rotor rotationally journalled in the casing.

8. A drive system as claimed in claim 6, in which the primary shaft is journaled in the motor through the rotor.

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9. A drive system as claimed in any of claims 4 to 8, in which the gearbox comprises two stages of gear reduction and a gear change mechanism.

10 10. A drive system as claimed in claim 9, in which the gear change mechanism comprises a shift ring for an intermediate planet gear ring rotationally mounted on the primary shaft and driving the hub, which shift ring is lockable to one of the primary shaft and the housing by a  
15 shift element.

11. A drive system as claimed in claim 10, in which the planet gear ring drives the hub through one or two fixed ratio gear sets.

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12. A drive system as claimed in claim 10 or 11, in which the shift mechanism comprises a shift element slidable between two positions, in a first position locking the shift ring to a housing gear ring, and in a  
25 second position locking the shift gear ring to a primary shaft ring.

13. A drive system as claimed in claim 12, in which the shift element includes a ferromagnetic disc axially  
30 shiftable by solenoids mounted in the housing.

14. A drive system as claimed in claim 12, in which the shift element comprises a magnetic sleeve shiftable by an induction coil mounted in the housing.

5 15. A drive system as claimed in any of claims 9 to 14, in which the gear change mechanism further includes active speed control of the motor during gear change to adjust dynamically the motor speed to the requisite speed commensurate with the desired gear ratio.

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16. A drive system as claimed in claim 15, in which said shift element is in a neutral position intermediate said first and second positions in which neither said housing gear ring nor said primary shaft gear ring is locked to  
15 the shift ring.

17. A drive system as claimed in claim 16, in which said active speed control comprises a motor speed sensor, a hub speed sensor and a control arrangement to accelerate  
20 or decelerate the motor in dependence upon which gear is selected.

18. A drive system as claimed in claim 17, in which said active speed control is in software.

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19. A drive system as claimed in any preceding claim, in which a brake disc is mounted on the hub and brake callipers are mounted on the housing.

30 20. A hub drive system for a vehicle, comprising:

a) a tubular housing suspended by the vehicle and

having inboard and outboard open ends;

b) a wheel hub rotationally mounted through hub bearings on the outboard end of the housing;

5 c) an electric motor disposed in the inboard end of the housing and comprising a stator fixed with respect to the housing and a rotor journaled for rotation in the housing;

10 d) a planetary gearbox, disposed in the outboard end of the housing and driven by the motor through a primary shaft coaxial with the rotor;

e) an output flange of the gearbox detachably connected to the hub and closing the outboard end of the housing; and

15 f) a gear change mechanism between the rotor and a first stage gear reduction of the gearbox to provide three options:

i) to interpose a further gear reduction stage ahead of said first stage reduction;

20 ii) to disconnect drive of the motor from the gearbox; and

iii) to isolate said further gear reduction stage and connect drive from the motor direct to said first stage.

25 21. A drive system as claimed in claim 20, in which the gear change mechanism comprises a shift element to effect gear change.

30 22. A drive system as claimed in claim 21, in which: an intermediate planet ring is journaled for rotation on the primary shaft and has a shift ring fixed thereon;

said shift element is movable between two positions, in a first of which it locks the shift ring to a primary

shaft ring, locked on the primary shaft, and in a second of which it locks the shift ring to a housing ring, locked with respect to the housing;

an intermediate sun gear, fixed on the primary  
5 shaft, transmits drive through planets mounted on an intermediate planet carrier;

said drive is without speed reduction when the shift ring is in said first position and said intermediate planet ring rotates at primary shaft speed, and, when the  
10 shift ring is in said second position, said drive is with speed reduction via said planets rolling between said intermediate sun gear and intermediate planet ring; and

said intermediate sun gear, intermediate planet ring and planets constitute said further gear reduction stage.

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23. A drive system as claimed in claim 22, in which said shift element has a third, neutral position in which the shift ring is locked to neither the primary shaft ring nor the housing ring.

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24. A drive system as claimed in claim 23, in which said neutral position is between said first and second positions, said shift element moving coaxially with respect to said primary shaft.

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25. A drive system as claimed in any of claims 21 to 24, in which said shift element is a ring surrounding said primary shaft, is provided with ferromagnetic elements and is disposed within the confines of a gear shift coil  
30 fixed in the housing and adapted to move the shift element by magnetic interaction.

26. A drive system as claimed in any of claims 20 to 25,  
in which said first stage gear reduction comprises a  
first sun gear, driven by the motor, planets, carried by  
a first planet carrier and driving said output flange,  
5 and a first planet ring fixed in the housing.

27. A drive system as claimed in claim 26 when dependent  
on claim 22, in which said first sun ring is formed on  
said intermediate planet carrier.

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28. A drive system as claimed in any of claims 20 to 27,  
in which the gearbox has a second stage reduction after  
said first stage and directly driving said output flange.

15 29. A drive system as claimed in claim 28, in which said  
second stage comprises a second sun gear, driven by the  
first stage gear reduction, planets, carried by said  
output flange, and a second planet ring fixed in the  
housing.

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30. A drive system as claimed in claim 29 when dependent  
on claim 26, in which said second sun ring is formed on  
said first planet carrier.

25 31. A drive system as claimed in any preceding claim, in  
which an air tube is disposed in the rotor and primary  
shaft to deliver air from a port in the casing to a port  
in the hub for controlling tyre pressure of a wheel  
mounted on the hub.

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32. A drive system as claimed in claim 31, when dependent on claim 1, in which the air tube is arranged to increase the rotor contact surface area per unit volume of lubricant flowing past the rotor at any given instant.

33. A drive system as claimed in claim 31 or 32, in which said air tube is fixed in the output flange, passages therein communicating with a port on the output flange to permit connection of a conduit to a tyre valve of a wheel mounted on the hub.

34. A drive system as claimed in claim 33, in which said air tube is rotationally mounted in an inboard end plate of the motor, passages therein communicating with a port on the end plate to permit connection of a conduit from a source of air under sufficient pressure to control inflation of the tyre, a rotary seal being disposed between said air tube and end plate.

35. A drive system as claimed in claim 34, when dependent on claim 1, in which said seal separates said passages in the endplate that communicate the air tube with said port on the end plate from said passage in the casing that delivers lubricant from said gallery to said hollow rotor.

36. A drive system as claimed in any of claims 1 to 3 in combination with a hub drive system as claimed in any of 4 to 19, or a hub drive system as claimed in any of claims 1 to 3 in combination with a hub drive system as claimed in any of 20 to 35, or hub drive system as claimed in any of claims 4 to 19 in combination with a



hub drive system as claimed in any of 20 to 35, or hub  
drive system as claimed in any of claims 1 to 3 in  
combination with a hub drive system as claimed in any of  
4 to 19 and in combination with a hub drive system as  
5 claimed in any of 20 to 35.

37. A hub drive system for a vehicle, substantially as  
hereinbefore described with reference to the accompanying  
drawings.

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38. A vehicle incorporating a hub drive system as  
claimed in any preceding claim.